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Jurassic and Early Cretaceous planktonic foraminifera (Favusellidae). Stratigraphy and paleobiogeography

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With 6 text figures and 2 tables

ABSTRACT

34 species of planktonic foraminifera of the Favusellidae are known in the Jurassic and Cretaceous (14 in the Jurassic and 20 in the Cretaceous). On the strenght of analysis corresponding layers were selected in the sections with determination of their stratigraphic range. It was cleared up that distribution area of Favusellidae in the Jurassic is streched in a narrow sublatitudinal strip from the eastern coast of Canada to the Middle Asia. It becomes significantly wide in the Cretaceous and moves to the south reaching the North Tropic in Berriasian-Hauterivian and South Tropic and Madagascar in the Albian-Cenomanian. Mediterranian region is suggested to be the possible centre of formation and expansion of the most early representatives of this family.

KURZFASSUNG

Aus dem Jura und der Kreide sind bisher 34 Arten von planktonischen Foraminiferen der Familie Favusellidae bekannt (14 aus dem Jura, 20 aus der Kreide). Die Vorkommen wurden weltweit in jeweils altersgleichen Schichten verglichen. Das Verbreitungsgebiet der Favusellidae ist im Jura beschränkt auf einen schmalen Streifen von der Ostküste Kanadas bis nach Mittel-Asien. In der Kreide dehnte sich das Verbreitungsgebiet nach Süden aus und erreichte im Berrias-Hauterive den nördlichen tropischen Bereich, im Alb-Cenoman den südlichen tropischen Bereich (Madagascar). Als Ursprungsgebiet kann die mediterrane Region angenommen werden, von wo die Ausbreitung der frühen Vertreter dieser Familie ausging.

INTRODUCTION

The abundancy and diversity of Late Cretaceous and Cenozoic planktonic foraminifera enables us to work out zonal scales of global significance. The beginning of the formation of this group of organisms can be associated with the Jurassic stage of the earth's evolution, during which planktonic foraminiferal assemblages as yet were few in number, and with limited distribution areas. Particularly the initial stage of the formation of this fauna is of great importance for understanding their further evolution.

Therefore, our task was to study early planktonic foraminifera of the family Favusellidae which have existed since the Middle Jurassic up to the end of the Early Cenomanian. The family Favusellidae was identified by LONGORIA (1974) as being part of one genus, *Favusella* MICHAEL 1971, and is defined as a unique group of Late Albian – Early Cenomanian globigerinids characterized by ornamentation of the surface of the test consisting of large polygonal plates looking as a honeycomb cell (LONGORIA, 1974, p. 74). Subsequently the number of the species identified as belonging to the family which besides the type genus *Favusella* now included two further genera: *Globuligerina* BIGNOT et GUYADER 1971, and *Conoglobigerina* MOROZOVA 1961 (GRIGELIS & GORBACHIK, 1980); their representatives having the surficial test ornamen-

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tation in the shape of a tubercle (pustule), or an irregular cell. Another specific feature of the family is the position of the aperture which is in most cases umbilical or intramarginal. The expansions of the family resulted in a change of opinions as to its stratigraphic distribution. The species making up the present family have been known to exist from the Bajocian to the Early Cenomanian inclusively.

The study of development of test-ornamentation of Favusellidae representatives from the Middle Jurassic to Cenomanian showed that it proceeded in accordance with the oligomerization principle, transformation from numerous diffusive ornamentation types-tubercles, to regular, larger and less numerous polygonal cells being seen (Alekseeva & Gorbachik, 1981). The regularity in development of the ornamentation confirms combination of the above mentioned genera into one family.

One of the problems, which still remains unsolved in the systematics of Favusellidae is the relationship between the genera *Conoglobigerina* and *Gubkinella* Suleymanov (1955). The former was described by Morozova (Morozova & Moskalenko 1961) from Bajocian-Bathonian deposits of Daghestan and was included into the family Globigerinidae as a subgenus of the *Globigerina* genus. The latter genus was attributed to the heterohelicids by Suleymanov (1955) and described from the Upper Senonian (Campanian-Maastrichtian) of the South-Western Kyzyl-Kum (Usbekistan). Subsequently Loeblich & Tappan (1964) also assigned *Gubkinella* to the Heterohelicidae and the genus *Conoglobigerina* was regarded as its junior synonym.

However, even without analysing the morphology of the above two genera, it would appear that between their Jurassic and Early Cretaceous representatives attributed by us to *Conoglobigerina*, on the one hand, and Senonian (Campanian-Maastrichtian) assigned to *Gubkinella*, on the other hand, there is a gap equivalent to at least four stages. This makes us doubt the validity of the concept. The problem posed can be solved by means of comparative analysis of the morphology of topotypes of *Conoglobigerina dagestanica* Morozova and *Gubkinella asiatica* Suleymanov. This is being included in the programme of our further studies.

This paper is mainly dedicated to the problem of stratigraphic and geographical distribution of representatives of the Favusellidae on a global scale, and their use for the solution of stratigraphy and correlation problems. The Favusellidae at the given stage of knowledge include the genera *Conoglobigerina, Globuligerina* and *Favusella*. The analysis of stratigraphic distribution of favusellids in the Jurassic and Cretaceous was carried out by Gorbachik and Grigelis (1982), the present new material, however, has made a considerable contribution to our knowledge.

STRATIGRAPHY AND PALAEOBIOGEOGRAPHY OF THE FAVUSELLIDAE

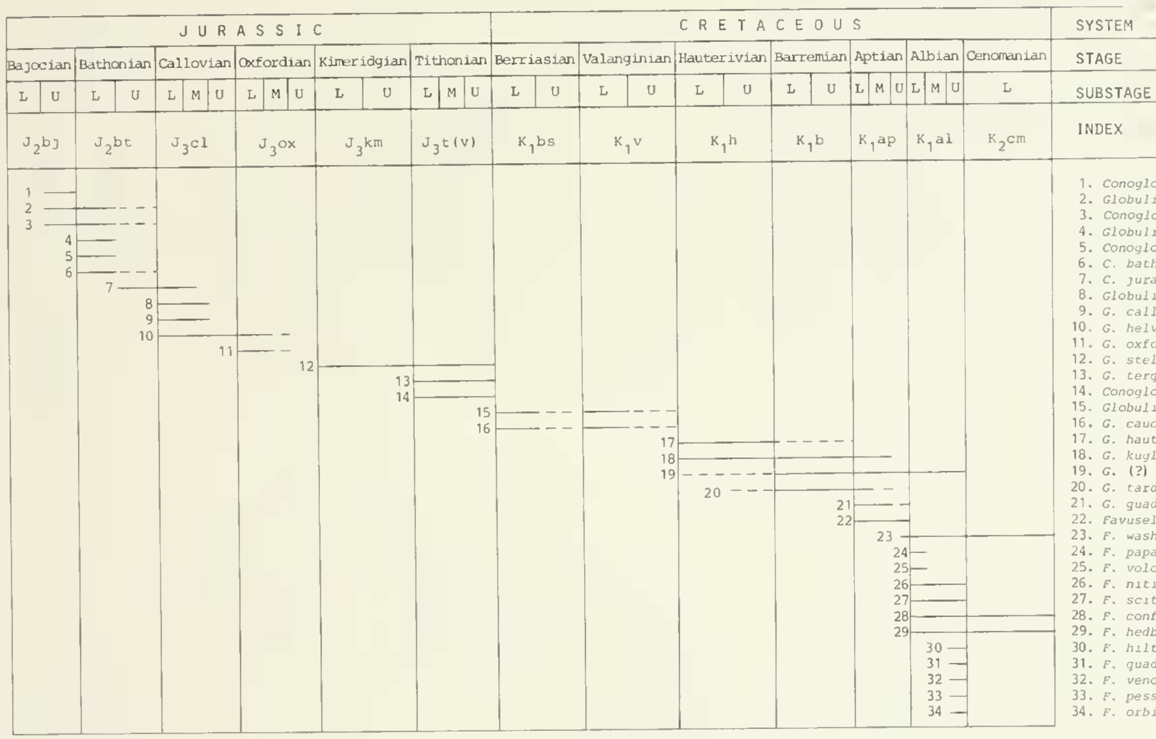
At present we are aware of 34 species of favusellids existing throughout the Jurassic and Cretaceous (14 species in the Jurassic and 20 species in the Cretaceous). Deposits from all the stages beginning from the Bajocian up to the Cenomanian inclusively, have been identified (Tab. 1). However, no favusellids have been observed as yet, in certain parts of this stratigraphic interval, i. e. they are missing in the Upper Oxfordian, Upper Berriasian and in the Upper Valanginian (the possible distribution of the species is shown in tab. 1 by broken lines).

The stratigraphic range of 11 species corresponds to one substage; nine species are distributed in two substages, including the adjacent stage. The remaining 14 species have a wider distribution. This can be related, to a certain extent, to the fact that the study of this extremely complicated group (small tests and too indistinct morphological features to be seen clearly under a light microscope) may not altogether be able enough. Especially complicated is the identification of these forms found in deposits in geosynclinal areas where preservation is less complete than those found in platform and oceanic deposits. One more circumstance should be taken into consideration: early planctonic foraminifera are seldom wholly distributed throughout a section, but are associated with separate beds; this is rarely stated in the available publications. As a result, we have an artifical spread of stratigraphical intervals of the species (Tab. 1). Thus, the subdivisions distinguished cannot as yet be regarded as zones, and are usually called beds.

Nevertheless, this group is undoubtedly important for the zonal subdivision of the Jurassic and Early Cretaceous, because the geographical distribution of favusellids, as with any planktonic foraminifera, is very wide. This makes correlation possible. The scheme of subdivisions of the Jurassic and Early Cretaceous using favusellid distributions, initially elaborated by Gorbachik and Grigelis (1982) and then supplemented by new data is shown in Tab. 2. The separate subdivisions are ambiguous with regard to their stratigraphic and correlative importance. The scheme presented has blanks for which no reprensentative species have been, as yet, identified (Upper Callovian, Upper Berriasian, Valanginian). These blanks seem not to be related to the absence of planktonic foraminifera but rather to a lack of material.

Some of the subdivisions are of a certain stratigraphic importance at a given stage in the study. They are represented by such species as *Globuligerina oxfordiana*, *G. helvetojurassica*, *Conoglobigerina bathoniana*, etc., having a narrow stratigraphic range and a very wide geographical distribution. These subdivision are traced from Crimea to Caucasus in the east and to the Canadian coast in the west.

Parts of the subdivisions are based on those species whose distribution areas are still limited. This is most probably related to a poor knowledge. No special studies of Cretaceous favusellids and their biogeography have been carried out till now. There are data available on this question in those publications containing identifications and descriptions of repre-



1. *Conoglobigerina gaurdakensis* Balachmatova et Morozova
2. *Globuligerina balakhmatovae* (Morozova)
3. *Conoglobigerina dagestanica* Morozova
4. *Globuligerina spuriensis* Bars et Ohm
5. *Conoglobigerina avarica* Morozova
6. *C. bathoniana* (Pazdrowa)
7. *C. jurassica* (Hoffman)
8. *Globuligerina meganomica* Kuznetsova
9. *G. calloviensis* Kuznetsova
10. *G. helvetojurassica* (Haeusler)
11. *G. oxfordiana* (Grigelis)
12. *G. stellapolaris* Grigelis
13. *G. terquemi* (Iovcheva et Trifonova)
14. *Conoglobigerina conica* (Iovcheva et Trifonova)
15. *Globuligerina gulekhensis* Gorbachik et Poroschina
16. *G. caucasica* Gorbachik et Poroschina
17. *G. hauterivica* (Subbotina)
18. *G. kugleri* (Bolli)
19. *G.* (?) *graysonensis* (Tappan)
20. *G. tardita* (Antonova)
21. *G. quadricamerata* (Antonova)
22. *Favusella* aff. *washitensis* (Carsey)
23. *F. washitensis* (Carsey)
24. *F. papagayonensis* Longoria
25. *F. voloshinae* Longoria
26. *F. nitida* Michael
27. *F. scitula* Michael
28. *F. confusa* Longoria
29. *F. hedbergellaeformis* Longoria
30. *F. hiltermanni* (Loeblich et Tappan)
31. *F. quadrata* Michael
32. *F. venoensis* Michael
33. *F. pessagnoi* Michael
34. *F. orbiculata* Michael

Table 1. Distribution chart of Favusellidae.

INDEX	SUBDIVISION
$K_1^{km}{}_1$	
$K_1^{al}{}_3$	[illegible] [illegible]lrata - [illegible]. washitensi[illegible]
$K_1^{al}{}_2$	Fav[illegible] n[illegible] - [illegible] [illegible]iltermanni
$K_1^{al}{}_1$	Favu[illegible] [illegible] - F. [illegible]
$K_1^{ap}{}_{1-3}$	Globuligerina quadricamerata - G. tardita
$K_1^{br}{}_{1-2}$	Globuligerina tardita - G. grayseonensis
$K_1^{h}{}_{1-2}$	Globuligerina hauterivica
$K_1^{v}{}_{1-2}$	-
$K_1^{bs}{}_2$	-
$K_1^{bs}{}_1$	Globuligerina gulekhensis - G. caucasica
$J_3^{t}{}_{1-3}$	Conoglobigerina conica - Globuligerina terquemi
J_3^{km}	Globuligerina stellapolaris
$J_3^{ox}{}_3$	-
$J_3^{ox}{}_{1-2}$	Globuligerina oxfordiana
$J_3^{cl}{}_3$	-
$J_3^{cl}{}_2$	Globuligerina calloviensis
$J_3^{cl}{}_1$	Conoglobigerina jurassica - G. meganomica
$J_{3bt_1}^{bt_2}$	Conoglobigerina bathoniana - C. avarica
$J_2^{bj}{}_2$	Conoglobigerina gaurdakensis - Globuligerina balakhmatovae
$J_2^{bj}{}_1$	-

Table 2. Scheme of subdivision of Upper Jurassic and Lower Cretaceous deposits, using favusellids.

sentatives of this group (Haeusler, 1881; Tappan, 1940; Subbotina, 1953; Grigelis, 1958; Hoffman, 1958; Bolli, 1959; Morozova & Moskalenko, 1961; Iovcheva & Trifonova, 1961; Antonova et al., 1964; Bars & Ohm, 1968; Michael, 1972; Grigelis et al., 1977; Longoria & Camper, 1977; Gorbachik, 1979; Gorbachik & Antonova, 1982; Kuznetsova & Uspenskaya, 1980; et al.) or in those devoted to the problems of the biogeography of Jurassic and Cretaceous foraminifera (Gordon, 1970; Dillay, 1971; Gradstein, Williams, Jenkins & Ascoli, 1975; Gradstein et al., 1977). This paper contains results of personal observations and analysis of DSDP which enables us to generalise on the global distribution of favusellids in the Jurassic and the Cretaceous (Fig. 1–6).

In the Middle Jurassic the distribution area of favusellids extended as a relatively narrow band in the sublatitudinal direction from the Transcaspian to the Eastern coast of Canada, almost reaching 60° Northern Latitude, in northern Europe, and 40° N. L. in the South. The composition of the Middle Jurassic plankton included six species attributed to the genera *Conoglobigerina* and *Globuligerina* (Fig. 1).

In the Late Jurassic the distribution of planctonic foraminifera expanded northwards to the Arctic Circle. The southern boundary of favusellids on the East coast of Canada reached 30° N. L. The most eastern occurence of planktonic foraminifera has been observed on the Gissar Ridge, from the Oxfordian deposits (Fig. 2). The tendency that the distribution area of this group shifts southwards is obvious from Early Cretaceous times. However, general orientation of the distribution area of planktonic foraminifera, having a sublatitudinal transatlantic location remains the same. The developmental area of the organisms under study expanded considerably to the west, covering California. Its eastern boundary in the Berriasian-Hauterivian was confined to the South-Eastern Caucasus. The southern boundary has reached the Northern Tro-

Fig. 1. Location of Favusellidae and their composition in the Middle Jurassic.

1. Crimea: *Conoglobigerina jurassica* ($bt–cl_1$).
2. North-East Caucasus (Dagestan): *Conoglobigerina avarica* (bt_1); *C. dagestanica* ($bj–bt_1$); *Globuligerina balakhmatovae* (bt_1).
3. South-East Caucasus (Azerbaijan): *Conoglobigerina gaurdakensis* (bj_2).
4. Turkmenia: Conoglobigerina gaurdakensis (bj_2); *Globuligerina balakhmatovae* (bt).
5. Poland: *Conoglobigerina bathoniana* (bt_{1-2}).
6. North Italy: *Globuligerina spuriensis* (bt);
7. Canada (shelf Nova Scotia): *Conoglobigerina bathoniana* (bt).
8. Canada (Grand Bank): *Globuligerina balakhmatovae* ($bj_2–bt$); *Conoglobigerina bathoniana* (bj–bt).

Fig. 2. Location of Favusellidae and their composition in the Upper Jurassic.

1. Crimea: *Globuligerina meganomica* (cl$_{1-2}$); *G. calloviensis* (cl$_{1-2}$); *Conoglobigerina jurassica* (bt–cl$_1$); *Globuligerina oxfordiana* (ox$_1$); *G. stellapolaris* (t$_1$); *G. terquemi* (t$_1$).
2. Gissar: *Globuligerina oxfordiana* (ox).
3. European part of the USSR (Moscow and Kostroma regions): *Globuligerina oxfordiana* (ox$_1$);
4. R. Pechora basin: *Globuligerina stellapolaris* (km$_1$).
5. Baltic region: *Globuligerina oxfordiana* (ox$_1$).
6. Bulgaria: *Globuligerina terquemi* (t); *Conoglobigerina conica* (t).
7. South of the FRG: *Globuligerina helvetojurassica* (ox$_1$).
8. Switzerland: *Globuligerina helvetojurassica* (ox).
9. France: *Globuligerina oxfordiana* (ox$_1$).
10. Sweden: *Globuligerina oxfordiana* (ox$_1$).
11. Canada (Grand Bank): *Globuligerina helvetojurassica* (ox$_1$); *G. oxfordiana* (ox$_1$); *G. meganomica* (cl).
12. Canada (shelf of Nova Scotia): *Globuligerina meganomica* (ce); *G. calloviensis* (ce).
13. DSDP Site 105: *Globuligerina helvetojurassica* (ox$_{1-2}$).

Fig. 3. Location of Favusellidae and their composition in the Early Cretaceous (Berriasian, Valanginian, Hauterivian).

1. Crimea: *Globuligerina gulekhensis* (v); *G. caucasica* (v).
2. South-East Caucasus (Azerbaijan): *Globuligerina gulekhensis* (bs$_1$); *G. caucasica* (bs$_1$).
3. North-West Caucasus: *Globuligerina hauterivica* (h).
4. Rumania: *Globuligerina hauterivica* (h).
5. France: *Globuligerina hauterivica* (h).
6. Tunisia: *Globuligerina hauterivica* (h).
7. Canada (shelf of Nova Scotia): *Globuligerina hauterivica* (h).
8. USA (California): *Globuligerina kugleri* (h).
9. Atlantic Ocean, DSDP Site 397: *G. kugleri; G. graysonensis* (h); Sites 370, 101, 105: *G.* (?) *graysonensis* (h).

Fig. 4. Location of Favusellidae and their composition in the Early Cretaceous (Barremian, Aptian).

1. Crimea: *Globuligerina kugleri* (b).
2. North-West Caucasus: *G. quadricamerata* (ap); *G. tardita* (b–ap_1).
3. Georgia: *G. hauterivica* (b).
4. Bulgaria: *Favusella washitensis* (ap_3).
5. Canada (shelf of Nova Scotia): *Favusella* aff. *washitensis* (ap); *Globuligerina hauterivica* (b).
6. Trinidad, *Globuligerina kugleri* (b–ap); *G. graysonensis* (b_2).
7. USA (Texas): *Globuligerina graysonensis* (b).
8. USA (California): *Globuligerina kugleri* (b);

Atlantic Ocean, DSDP Site 398: *G. quadricamerata* (ap); *G.* (?) *graysonensis* (b); *G. tardita* (ap); S. 397: *G. tardita* (b); S. 369, 363: *G.* (?) *graysonensis* (ap); *G. kugleri; G. hauterivica* (b); S. 391: *G. kugleri* (b); S. 101, 105: *G. hauterivica* (b–ap ?).

Pacific Ocean, DSDP Sites 49, 50, 306: *G. graysonensis* (b_2); S. 305: (b–ap ?).

Fig. 5. Location of Favusellidae and their composition in the Early and Late Cretaceous (Albian, Cenomanian).

1. Crimea: *Favusella washitensis* (al_3–cm).
2. South of the FRG: *F. washitensis* (al_3).
3. France: *F. washitensis* (al_3).
4. Portugal: *F. washitensis* (al_3–cm).
5. Sardinia: *F. washitensis* (al_3).
6. Israel: *F. washitensis* (cm).
7. Algeria: *F. washitensis* (al_3).
8. Libia: *F. washitensis* (cm_1).
9. Zululand: *F. washitensis* (al_3).
10. Madagascar: *F. washitensis* (al_2).
11. Trinidad: *Globuligerina* (?) *graysonensis* (al_2–cm).
12. USA (Texas): *G. graysonensis* (al_2–cm_1); *F. washitensis* (al_3–cm); *F. nitida, F. scitula, F. quadrata, F. wenoensis, F. pessagnoi, F. orbiculata* (al_3); *F. hiltermanni* (al_{2-3}).
13. USA (Oklahoma): *G* (?) *graysonensis* (al_2–cm_1).
14. USA (Minnesota): *G.* (?) *graysonensis* (al_2–cm_1).
15. Mexico: *F. washitensis* (al_1–cm); *F. papagayonensis, F. voloshinae* (al_1); *F. nitida, F. scitula* (al); *F. confusa, F. hedbergellaeformis* (al–cm).
16. Cuba: *F. washitensis* (al_2–cm).
17. Hokkaido: *F. washitensis* (cm_{2-3}).

Atlantic Ocean, DSDP Sites 370, 398: *F. washitensis* (al); S. 402: *F. washitensis* (al_2); *F. washitensis* (al_1).

pics, whilst the northern one did not exceed 45° N. L. (Fig. 3).

The systematic composition of planktonic foraminifera at that time somewhat varies; the specific composition being completely renewed; four of the five known species belong to the genus *Globuligerina*, and one *(G.* [?] *graysonensis)* is attributed by various authors to different genera: *Globuligerina*, *Gubkinella*, *Globigerina*.

Subsequently, during the Barremian and Aptian favusellids spread in the latitidunal and meridional direction was observed. Their distribution was associated with a sublatitudinally oriented area, the transatlantic and transpacific. The global distributional area is only interrupted in Central Asia, represented by continental facies (Fig. 4). During the Barremian and almost the entire Aptian the favusellids were, as previously, represented by the genus *Globuligerina* (5 species); and only at the end of the Aptian did the first representatives of *Favusella* (2 species) appear.

In the Albian and Early Cenomanian the southern boundary reached, as before, the Southern Tropics of South Africa and Madagascar. The systematic composition increased noticeably, i. e. it included 13 species of favusellids attributed mostly to the genus *Favusella* (12 species) (Fig. 5).

CONCLUSIONS

So, following the history of development and distribution of planktonic foraminifera from the Middle Jurassic up till the beginning of the Late Creaceous, the following can be said:

In the Jurassic and specially in the late Jurassic the distribution areas of planktonic foraminifera have had a much more northern occurrence than in the Cretaceous. This, so we believe, is directly related to climatic conditions. At the end,of the Jurassic the average yearly temperature of the water masses in the Boreal sea was very high, from 21° to 24° C (Saks & Nalnyaeva, 1966). This corresponds to the temperatures of the recent Sea of Japan and the Gulf of Mexico, i. e. subtropical basins.

A gradual cooling of the epicontinental basins of the Boreal belt led to a subsequent migration of planktonic foraminifera towards the South in the area of the Tethys and Paratethys, where the water temperatures remained high (Fig. 6).

The analysis of the distribution areas and their successive changes, including transformations in the systematic composition of favusellids show that their earliest representatives have been found in the Crimean-Caucasian province of the Mediterranean area. The same were inhabited by almost all known Early Cretaceous favusellids up till the Albian time. Therefore, the Mediterranean area appears possibly to be the centre of the formation and distribution of the early plankton.

Fig. 6. Areals of spreading of the Jurassic and Early Cretaceous Favusellidae. 1 = Middle Jurassic; 2 = Late Jurassic; 3 = Berriasian, Valanginian, Hauterivian; 4 = Barremian-Aptian; 5 = Albian-Early Cenomanian.

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